12/20/00
375/292

APPARATUS AND METHOD FOR BIT DISPARITY DETECTION

FIELD OF THE INVENTION

This invention relates to communications networks and in particular to an improved apparatus and method for bit disparity detection in optical communications networks.

BACKGROUND OF THE INVENTION

High bits (1's) and low bits (0's) within a data stream are preferably equal in number over a set period of time. Bit disparity is a condition whereby the balance of 1's and 0's in a signal deviates from a 1:1 ratio. Over a sufficiently large period of time it is expected that the number of 1's sent will be equal to the number of 0's sent, that is, the 1's density in a signal will be 50%. Non-compliant bit disparity refers to a situation in which the bit disparity exceeds an acceptable threshold, either because of an unacceptably high or low 1's density.

There are a number of reasons that high bit disparity can occur.

First, there are a number of data protocols which have been identified to have reasonable potential to exhibit non-compliant bit disparity, including 100Base-FX, a physical layer standard of Fast Ethernet, and FDDI (Fibre Distributed Data Interface), which are both encoded with 4B/5B coding and NRZI. 4B/5B coding is a method of line coding which translates each set of 4 bits into a corresponding set of 5 bits. NRZI (Non-return-to-zero inverted) is a coding which causes the output to transition on a '1' and not transition on a '0'. The combination of 4B/5B and NRZI is intended to provide sufficient scrambling (density of 0-1 and 1-0 transitions) and disparity control to make the signal

suitable for optical transmission. However, there are some data patterns that still exhibit non-ideal 1's density, even after 4B/5B and NRZI coding. The codes are such that some codes may exhibit 1's density of 40% or 60%. If such like codes persist, the average 1's density may approach the acceptable limits of bit disparity. While either protocol carrying real traffic is not expected to exhibit this condition, test patterns may do so and the possibility always exists that real traffic will exhibit this condition as well.

Similarly, digitized video signals (D1 video) can contain patterns consisting of concatenated code words containing 19 0's and a single 1, resulting in a 1's density of 5%.

Second, it is possible that a compliant data signal may be degraded by the hardware of the optical network, or the link between the customer and the network, such that the bit disparity exceeds acceptable limits. While rare, such occurrences frequently involve failed components or connections.

When bit disparity is non-compliant, the integrity of the data passing through an AC-coupled system will be degraded, resulting in bit errors or false alarm signals. This degraded signal performance may be manifested in a number of ways.

First, AC coupling between functional blocks in the high speed path of an optical network cannot support signals exhibiting persistent non-compliant bit disparity and may, in an extreme case, result in single or even multiple bit errors.

Second, while the optical system of the lasers used in an optical network is designed to accommodate a certain amount of power variation, high bit disparity may cause a power variation in excess of the acceptable threshold.

resulting in bit errors in the affected channel. Further, the biasing of the laser may be affected such that the laser produces side modes in adjacent channels, resulting in bit errors in these channels as well.

Third, the difference between the laser output power and the expected power is frequently monitored as an equipment alarm condition. Where the 1's density is high, the output power may appear to change sufficiently to incorrectly trigger this alarm condition.

Fourth, a fluctuation in the mean power of any of the wavelengths traversing an optical amplifier will cause amplitude modulation of other wavelengths traversing the same amplifier. The effect is most pronounced if the fluctuation wavelength is high in power relative to the total optical power entering the amplifier. A variation in the bit disparity affects directly and almost linearly the mean optical power of a signal. Accordingly, minimizing bit disparity will help to mitigate this amplitude modulation effect.

Therefore, if bit disparity could be monitored, one would adjust thresholds and raise alarms. Additionally, a network could warn the user that good performance cannot be guaranteed, because of high bit disparity in the incoming data.

There are some data protocols which are designed to provide balanced signals, that is, signals with little or no bit disparity. Examples include SONET, which is scrambled using a pseudo-random bit sequence XOR'ed with the raw data, and 8B/10B coding, in which very tight disparity control was part of the coding design. When such signals are used, there is no need for a bit disparity monitor. However, many factors govern the choice of a data protocol, and low bit disparity is not typically one of significance to the

customer, who chooses the data protocol to be used. Many data protocols presently used in optical communications were originally intended to be carried in the electrical domain, where bit disparity is of little or no significance.

One possible implementation for bit disparity detection is to demultiplex the signal and reduce the transmission rate to one at which the high and low bits could be counted and compared. This requires more circuitry and processing than can be justified merely for this purpose.

An analog implementation for bit disparity monitoring contemplates the use of a low pass filter to find the mean power of the data stream. If there is low bit disparity, the mean power will lie directly between the power of the high and low bits. Such an approach has been useful to provide a feedback parameter into the laser driver control loop to adjust the laser parameters, without actually monitoring the bit disparity. One problem with this implementation is that the time period over which the bit disparity is determined is fixed dependent upon the bandwidth of the low pass filter utilized. Further, such an implementation requires the use of an A/D converter to determine an actual value for the bit disparity, if the actual value is required.

SUMMARY OF THE INVENTION

Accordingly, embodiments of the present invention provide an apparatus and method for bit disparity detection.

In a first embodiment of the present invention, samples of the data stream are obtained and each sample is interpreted as a 1 or a 0. The total number of 1's so sampled over a time period is determined and statistical analysis is applied to determine a bit disparity value for the time